Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service	)))))	ET Docket No. 95-18

JOINT COMMENTS OF THE ASSOCIATION FOR MAXIMUM SERVICE TELEVISION, INC. AND OTHER MAJOR TELEVISION BROADCASTING ENTITIES

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The Association for Maximum Service Television, Inc. ("MSTV"), Capital Cities/ABC, Inc., CBS Inc., Chris-Craft/United Television Stations Group, Fox Television Stations, Inc., the National Association of Broadcasters, National Broadcasting Company, Inc., Public Broadcasting Service, and the Radio-Television News Directors Association ("RTNDA") (the "Joint Commenters") hereby file comments in response to the supplemental comments of COMSAT Corporation, filed on March 14, 1996 ("COMSAT Supplemental Comments"), which the Commission put out on Public Notice on April 17, 1996.[1/]

[1/] MSTV is a non-profit trade association of local broadcast television stations committed to achieving and maintaining the highest technical quality for the local broadcast system. NAB is a non-profit, incorporated association of radio and television stations and networks which serves and represents the American broadcast industry. RTNDA is the principal professional association for those involved in electronic journalism in the United States. MSTV, NAB, RTNDA, and the other Joint Commenters have a longstanding and vital interest in maintaining the viability of free, universal, over-the-air television broadcasting, and are deeply concerned about the need for continued uninterrupted access to sufficient auxiliary broadcast spectrum.

INTRODUCTION AND SUMMARY

This proceeding concerns the spectrum bands that mobile satellite services ("MSS") seek to use for their satellite uplinks (1990-2025 MHz) and downlinks (2165-2200 MHz). Terrestrial broadcasters use the 1990-2110 MHz band very intensely to operate seven channels in all local markets across the country for broadcast auxiliary services ("BAS"), including the crucial electronic newsgathering ("ENG") that supports live local newscasts. Two of these channels occupy the proposed MSS uplink spectrum. Fixed microwave services ("FS") currently use the prospective downlink spectrum.

On, January 31, 1995, the FCC proposed to reallocate the 1990-2025 MHz band to MSS on the condition that MSS newcomers would pay to move the incumbent BAS operators to the 2110-2145 MHz band and relocate the incumbent fixed microwave services. See Notice of Proposed Rulemaking, ET Docket No. 95-18 the "Notice"). This proposal embodied two basic principles - that incumbents should be relocated to specific and appropriate spectrum and that the newcomers should fully fund such moves.

COMSAT, a prospective occupant of the proposed reallocation, sought to overturn these principles. It urged that the MSS industry be spared the costs of relocating incumbents. This could be done by shifting MSS start-up costs to the occupants of the uplink bands, who it suggested could narrow their BAS channels by almost one-third, and to occupants of the downlink bands, who it suggested could share

the spectrum with MSS operations. Specifically with respect to BAS, COMSAT proposed that BAS operations be expelled from the 1990-1998 MHz band by 1998 and from the 1998-2025 MHz band by 2005.[2/]

On March 14, 1996, COMSAT filed supplemental comments largely restating its original position with respect to both the uplink and downlink spectrum. COMSAT's stated reason for reopening the record was that the World Radio Conference of 1995 ("WRC-95") had concluded that "sharing between MSS and existing FS systems at 2 GHz is feasible as part of a gradual transition arrangement" and that because COMSAT's phased transition plan assumed sharing and a gradual transition, the Commission should reexamine COMSAT's plan in light of WRC-95.[3/] Other MSS proponents strongly reject the possibility of sharing downlink spectrum with FS, as do FS operators themselves.[4/] As discussed below, the Commission should not adopt any allocation premised on MSS-FS sharing at

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[2/] See Comments of COMSAT Corporation, ET Docket No. 95-18 (May 5, 1995) ("COMSAT Comments"), at 18-24. The proposals of other MSS proponents varied. For example, Motorola urged the Commission to relocate all BAS operations to spectrum above 2 GHz. See Comments of Motorola, ET Docket No. 95-18 (May 5, 1995), at 19. This proposal, like COMSAT's, was unrealistic. That it was based on assumptions so totally different from those of COMSAT, and that both sets varied so wildly from the Commission's original assumptions, suggests that a decision made on either proponent's assumptions would be indefensible. See Reply Comments of MSTV and Other Major Television Broadcasting Entities, ET Docket No. 95-18 (June 21, 1995), at 10-14 ("Joint Reply Comments").

[3/] See COMSAT Supplemental Comments, at 7.

[4/] See Comments of Motorola; Comments of UTC; Comments of API; Comments of APCO; ET Docket No. 95-18 (May 5, 1995).

least until the technical viability of that premise is proven.

A small portion of the COMSAT Supplemental Comments is devoted to a revised BAS spectrum proposal that would commence Phase I of the transition in 2000 instead of 1998 and designate BAS as a secondary service in the 1998-2025 MHz band in 2000. Not even COMSAT asserts that the WRC-95 proceedings bear directly on its proposed BAS transition scheme. In fact, the COMSAT Supplemental Comments supply no new evidence to support the original or revised COMSAT position on the uplink bands. They point to no fact that would alter the realities of current BAS operations -- the bandwidth that is required to transmit acceptable video in an unfriendly terrestrial environment, the increasing use of BAS facilities, or the right of an incumbent to be reimbursed and relocated upon any MSS occupation of the 1990-2025 MHz band.[5/]

To ensure that the public continues to receive first-rate and expanding broadcast news and special event

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[5/] Such a relocation plan should include the following features of the Commission's proposed plan, see Notice, at ¶ 11: MSS providers should shoulder all costs associated with the relocation, including those related to the relocation of the services currently operating in the 2110-2145 MHz band; the new facilities should be state-of-the-art and fully comparable to the existing facilities; and incumbent services should be successfully relocated from the 2110-2145 MHz band before broadcasters are required to vacate the 1990-2025 MHz band and relocate to the 2110-2145 MHz band. These principles are the same principles articulated in the PCS proceeding. See In the Matter of Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies (Third Report & Order), 8 FCC Rcd. 6589, 6591, 6602-04 (1993); In the Matter of Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies (First Report & Order), 7 FCC Rcd. 6686, 6890 (1992).

coverage in both analog and digital formats, the Commission should adhere to its initial proposal with respect to the BAS transition. In all events, the Commission should not fatally disrupt BAS operations for the sake of a purely hypothetical and unproven transition plan premised on MSS and FS frequency sharing.

I. The Commission Should Not Adopt an MSS Allocation and Transition Plan Predicated on MSS-FS Frequency Sharing Unless the Plan Has Been Proved Technically Feasible.

COMSAT's proposal that the existing FS and BAS operators transition out of, respectively, the prospective downlink and uplink spectrum in two phases by 2005 is based on two technical assumptions: that MSS and FS can share frequencies and that BAS can operate on channels of substantially reduced bandwidth. The first assumption regarding FS is unproven and the second assumption regarding BAS has been proven wrong. These comments address each assumption in turn.

COMSAT asserts that the "clear intent of the Resolution [COM 5-10 of WRC-95] is that it is feasible to share spectrum in the 2 GHz MSS downlink bands in the near term and to implement a gradual transition of FS systems over the long term to non-overlapping portions of the 2 GHz bands."[6/] In fact, the Resolution is far more circumspect. It refers to studies showing that "while sharing of the MSS with the fixed service in the short to medium term would be

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6/ COMSAT Supplemental Comments, at 8.

generally feasible in the long term sharing will be complex and difficult in both bands." The conclusion reached from the uncertain success of sharing is "that it would be advisable to transfer the fixed service stations operating in the bands in question to other segments of the spectrum."[7/] All that can be gleaned from the COMSAT Supplemental Comments is that the Resolution neither recommends nor expressly discourages the sort of temporary FS-MSS sharing COMSAT proposes -- hardly a strong endorsement for derailing the Commission's initial plan or the technical assumptions on which it was based.

As Motorola notes: "Other than its interpretation of WRC-95's Resolution Com 5-10, COMSAT provides no additional technical evidence as to the ability of operational MSS systems to share downlinks with FS systems on a co-frequency basis. Without more, the Commission must be wary of proceeding down a technically unproven sharing path."[8/] Whatever the conferees at WRC-95 might have concluded about the feasibility of sharing is tangential to this proceeding. The Commission should make its own determination based on a fully developed technical record.[9/] Without a substantial degree of certainty on this issue, BAS and FS incumbents might

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[7/] Final Acts of the World Radiocommunication Conference, Part II, Res. COM 5-10, Consid.(c).

[8/] Partial Opposition of Motorola to COMSAT's Motion for Leave to File Supplemental Comments, ET Docket No. 95-18 (March 27, 1996) at 3.

[9/] See Motorola Petition, at 3.

be required to bear the substantial risk that COMSAT's unproven sharing plan would fail.

II. The Commission Should Not Abandon the Reasonable BAS Transition Plan it Proposed for an Alternative Plan Based on Unrealistic Channel Designs.

COMSAT's Supplemental Comments propose a Phase I reduction in BAS spectrum of 8 MHz by 2000, thus shrinking BAS channels to 16 MHz, and a Phase II reduction of another 27 MHz by 2005, thus shrinking BAS channels to 12 MHz.[10/] This proposal is unworkable, unfair, and would impair the public's broadcast service. Part and parcel of the gradual transition plan that is predicated on MSS-FS sharing, the BAS component of the plan should not be considered until uncertainty about the frequency sharing has been resolved. Moreover, the BAS component of the COMSAT plan should be rejected independently because it is technically unsound.

A. BAS Use is Heavy, Growing and Data Rich.

The record in this proceeding is replete with evidence that broadcasters use the seven BAS channels in the 2 GHz band (two of which are in the 1990-2025 MHz band) intensively, efficiently, and on a shared basis nationwide. BAS operations provide critical support for free over-the-air

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[10/] COMSAT also proposes that BAS operations in the 2008-2025 MHz band be designated as secondary to MSS uplink operations beginning in 2000. Because, as COMSAT recognizes, BAS and MSS operations cannot share spectrum, there is some question as to what secondary status would mean and whether implementing this proposal would in fact require BAS operations to cease altogether in the relevant bands by the year 2000. See COMSAT Supplemental Comments, at 15-18.

newscasts. Increasingly, local news operations are dispatching news trucks to provide live coverage of breaking events in their own communities and across the country. In any given community, local television stations share the BAS spectrum to relay the live ENG transmissions back to their studios for transmission over the main channel. ATV transmissions simulcast with the analog transmissions will increase the frequency of BAS use.[11] Moreover, the greater data load of ATV signals will put pressure on the size of the BAS channel.[12]

BAS operations have outgrown their existing spectrum allocations in the 2 GHz band and will be stretched even further due to the demands of digital broadcasting. The Joint Commenters have submitted a large body of evidence, drawn from NTIA and other government studies, showing that the BAS 2 GHz spectrum is already overcrowded and BAS analog use alone is growing by 15% per year.[13] Frequency coordinators in the top 25 markets testify to the spectrum congestion that

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[11] COMSAT reiterates in its Supplemental Comments what it first raised in its Reply Comments -- that a freeze should be imposed on new BAS licenses in the 2008-2025 MHz band. See COMSAT Supplemental Comments, at 15; COMSAT Reply Comments, at 10. Such a freeze would be reasonable if BAS operations were relocated to suitable spectrum as the Commission proposed. However, a freeze could devastate the development of ATV if replacement spectrum is not found for BAS operations because broadcasters will have to seek licenses for auxiliary services in support of ATV.

[12] See Joint Reply Comments, at 7-8.

[13] See, e.g., Comments of MSTV and Other Major Television Broadcasting Entities, ET Docket No. 95-18 (May 5, 1995) at 4-10 ("Joint Comments"); Joint Reply Comments, at 5.

impinges on BAS operations. According to a survey done last year, all coordinators found the 2 GHz BAS band congested and 78% stated there was inadequate spectrum to accommodate the BAS operations that ATV will require.[14/] Because of these difficulties, broadcasters sought an additional BAS allocation in the 4 GHz band (4660-4685 MHz), but were denied.[15/]

Even without the pressures created by MSS entry into the 2 GHz spectrum, broadcasters would have every incentive to economize on their BAS spectrum use. The central constraint on such efforts is that the pictures broadcast on BAS spectrum need the exceptional clarity that only relatively wide bandwidth can provide in the terrestrial environment. These pictures must be of "contribution quality" -- that is, of high enough quality to survive the inevitable degradation the signal suffers between the remote site and the studio, through processing, and then to the viewer's home.[16/]

[14/] See Joint Comments at 4-10 and Hammet & Edison, Inc., 2 GHz Usage Survey (May 1995) (Attached thereto as Exhibit B).

[15/] See generally Comments of MSTV and Other Major Television Broadcasting Entities, ET Docket No. 94-32, at 5-9 (December 19, 1994) (urging that the Commission allocate the 4660-4685 MHz band to forthcoming advanced digital broadcast auxiliary operations) and Petition for Reconsideration of MSTV and Other Major Television Broadcasting Entities, ET Docket No. 94-32, at 3-5 (April 6, 1995) (same).

[16/] See Joint Comments at 17-18. See also Engineering Statement of Michael J. Strein, Capital Cities/ABC (May 16, 1996), at 1 (Attached hereto as Exhibit A).

Achieving this quality has generally required 17 MHz channels for analog transmissions.[17] Innovations in digital BAS technologies might permit the compression of signals to 16 MHz channels, although there is some doubt about this. Signal quality would certainly begin to degrade at 15 MHz, and bandwidths that are even narrower would unacceptably impair the picture and sap ENG of its value.[18]

B. COMSAT's Proposal Ignores How BAS Functions in the Real World.

Even absent any displacement from their existing 2 GHz allocation, the great challenge for BAS operators would be to squeeze new and multiplying uses into their existing allocation. The orderly transition to the 2110-2145 MHz band contemplated by the Commission would still require broadcasters to cope with the disruption of relocating and retooling. But the Herculean challenge that COMSAT proposes -- to squeeze burgeoning BAS activities into narrower channels using non-existent equipment on the basis of unproven theories -- simply cannot be met.

COMSAT's transition plan depends on the viability of 12 MHz BAS channels, amounting to a 30% reduction in BAS bandwidth. All reliable evidence points against the likelihood that channels as narrow as 12 MHz would suffice to

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[17] Channel "splitting" has been used successfully only under certain technically restricted circumstances or with a reduction below true contribution quality. See Joint Comments, at 18.

[18] See Joint Reply Comments, at 7-10.

transmit contribution quality signals along the non-engineered paths terrestrial broadcasters use.[19] It is true that signals may be squeezed into narrower bands through digital compression and higher-order-modulation schemes. However, if highly compressed signals are subjected to higher-order-modulation schemes in an interference-prone terrestrial environment, there will be frequent signal failures as the signal passes through foliage and around buildings to the studio.

COMSAT defends its proposal by pointing to the narrow bandwidth transmissions of satellite Direct-To-Home video services, which it admits do not achieve contribution quality, and satellite transmissions using MPEG II compression and a satellite-friendly modulation scheme.[20] However, what can be done via satellite has little relevance to terrestrial microwave paths or broadcasting. As the engineering statement attached at Exhibit A shows, even a maximally compressed video signal (19.5 Mb/s) cannot fit into 12 or even 15 MHz channels. This is because the signal requires a modulation scheme "robust enough to survive transmission in an urbanized area,

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[19] See Joint Reply Comments, at 5-7 and Engineering Statement of Jules P. Cohen (June 15, 1995), at 2-4 (Attached thereto as Exhibit A). The very Society of Broadcast Engineers comments that COMSAT cites in support of its position in fact undermine it. These comments state that 12 MHz BAS channels will not provide acceptable video quality. See Comments of the Society of Broadcaster Engineers, ET Docket No. 95-18 (May 5, 1995), at 4-8; COMSAT Supplemental Comments at 16, n. 27.

[20] See COMSAT Reply Comments, at 14.

where RF use is intensive and congested and where available microwave paths are usually lossy and sometimes even completely obstructed."[21] Even using state of the art transmission and compression technologies, the "higher modulation techniques, such as 16 QAM or 64 QAM . . . are too fragile to survive the phase and amplitude distortions caused by transmission along paths typical for ENG use."[22]

COMSAT's claims that BAS can function effectively on severely shrunken channels are not supportable. It contends that the Comsat/Wegener VideoLynx 2000 compression system can provide contribution quality video and associated audio "with a robustly encoded, high-level modulation signal that provides a quality signal in a minimum bandwidth."[23] COMSAT delivered a prototype of this system to the Capital Cities/ABC engineering laboratory for testing last summer. As detailed in the attached technical report, the system performed badly in transmitting video with high detail and motion. Delays and the loss of several active video lines and a loss of the vertical blanking interval lines (used for closed captioning) were among its other deficiencies.[24]

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[21] See Engineering Statement of Michael J. Strein, at 2.

[22] Id.

[23] See COMSAT Comments, at 22, n.14.

[24] See attached Engineering Statement of Michael J. Strein (May 16, 1996). One of the practical problems with the COMSAT prototype is its size. Because it is three rack units high, 30 pounds, and not mounted in a weatherproof package, it is wholly unsuited for a common application of ENG -- point-of-view cameras mounted on high motion vehicles.

C. There are No New Facts to Remedy the Existing Faults in COMSAT's Proposal.

The above points are amply vetted in the comments and reply comments that form the existing record of this proceeding. COMSAT's ostensible reason for supplementing that record is that WRC-95 changed things. However, the most that COMSAT can assert is that the WRC-95 conclusions are "consistent" with its own two-phased transition plan, not that the WRC-95 proceedings in any way endorsed either the FS or BAS components of COMSAT's plan.[25] If anything, the WRC-95 conclusions drain COMSAT's proposal of some of its force.

With respect to BAS spectrum, COMSAT's proposal contravenes the spirit of the WRC-95 COM5-10 Resolution. That Resolution urges administrations to find replacement spectrum for incumbents displaced from MSS bands.[26] COMSAT, however, would have the Commission shrink BAS channels without providing for the transfer of BAS to non-overlapping bands.

More generally, WRC-95 has raised questions about the very necessity for the global MSS allocation COMSAT desires to obtain cost-free. Before WRC-95, there was at least some possibility that the international allocation for MSS would be coextensive with the 1990-2025 MHz proposed FCC allocation. We now know that the ITU has limited the global MSS allocation to the 1990-2010 MHz uplink and 2170-2200 MHz

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[25] See COMSAT Supplemental Comments, at 2, 11.

[26] See Final Acts of the World Radiocommunication Conference, Part I, Res. COM 5-10, Resolve 4.3.

downlink bands. The 2010-2025 MHz extension bands will be available only in the U.S. and Canada, thus eliminating the possibility that COMSAT could offer the "global" MSS that it repeatedly states is at issue here.[27] COMSAT placed some reliance on the fact that even if there were no global MSS allocation in the extension bands at WRC-95, a program would be implemented to study the issue for WRC-97.[28] There is no indication that such a program was implemented. The global MSS allocation in the extension bands that COMSAT desires is now even more uncertain than it was one year ago.

The Commission should determine whether it is still worthwhile to allocate the 2010-2025 MHz band for what will, at least for the foreseeable future, be a regional MSS system. But beyond this, the Commission should examine the justification for COMSAT's transition proposal in light of the truncated international allocation. COMSAT sought to avoid paying to relocate incumbent BAS and fixed microwave services because it asserted that such payments would be too high, especially if MSS operators had to make such payments around the world.[29] At least with respect to the 2010-2025 MHz band, it is now quite clear that such payments would not be required outside of Region 2 and fulfilling its obligation to retrofit incumbents and resettle them in a suitable spectrum

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[27] See, e.g., COMSAT Comments, at 11-15; COMSAT Supplemental Comments, at 2.

[28] See COMSAT Comments, at 16, 21.

[29] See COMSAT Supplemental Comments, at 13.

would be a reasonable cost of doing business for the MSS operators.[30]

CONCLUSION

COMSAT's transition proposal for the 2 GHz band assumes that MSS and FS can share spectrum and that BAS can operate successfully on 12 MHz channels. The first proposition is unproven and disputed even by other MSS proponents. The second proposition has been proven false. An MSS allocation based on these faulty assumptions would heavily tax BAS operators and the public they serve without any sound justification. The Commission's initial proposal to require MSS to relocate FS and BAS operations remains the best. The public interest will not be served by diminishing the ability of its local newscasts to cover events and the quality of the coverage that is offered. We urge the Commission to conclude

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[30] By COMSAT's own calculations, the cost of moving BAS incumbents from the 1990-2025 MHz band according to the Commission's plan is $275 million, see COMSAT Comments, at 13, which is a fairly small chunk of the total $3 billion it estimates it would cost to move both BAS and FS incumbents. See COMSAT Supplemental Comments, at 3, 13. Thus, if COMSAT is correct in asserting that MSS can share the downlink spectrum, its total costs in moving incumbents from the newly allocated MSS bands would be manageable.

this proceeding by adopting its initial proposal, as modified by the suggestions previously made by the Joint Commenters.

Respectfully submitted,

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May 17, 1996

Exhibit A

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Engineering Statement Of Michael J. Strein, Capital Cities/ABC

I am Manager of Technology and Equipment Planning for the Broadcast Operations and Engineering Division of the ABC Television Network. My specific responsibilities include running the day-to-day operations of the ABC Engineering Lab. I have been with ABC since 1990 and have held my current position since 1994. I graduated with a Bachelor's Degree in Electrical Engineering Technology from the SUNY Institute of Technology at Utica/Rome in 1983. I held the position of Test Engineer with Standard Microsystems Corporation, based in Hauppauge, New York, before I came to ABC. The tests and evaluations described herein were conducted by me or under my supervision.

Abstract

The ABC Engineering Lab has tested and evaluated a prototype of the Comsat/Wegener VideoLynx 2000 compression system, supplied to us by Comsat/Wegener in July, 1995. ABC has not previously made public these test results because Comsat/Wegener repeatedly assured us that a final, production version would be provided to us for re-evaluation. This has yet to occur, despite various promised due dates. However, Comsat has continued to make filings and presentations to the FCC concerning spectrum reallocation which are largely based upon claims made about the performance of this device, responses to which filings are now due. Accordingly we are now reporting our test results. In brief, our laboratory tests do not support the claims made by Comsat in Footnote 14 of their Comments filed in ET Docket 95-18 on May 5, 1995, concerning the capabilities of this system to provide "Contribution Quality" video in small bandwidths.

Uses of 2 GHz Spectrum

The 2 GHz spectrum used by broadcasters is commonly, and over-simplistically, referred to as "ENG" channels. The fact is that while this spectrum is often used for Electronic News Gathering purposes, it is also used for Point Of View (POV) camera transmission such as blimp cameras, cameras situated on race cars, etc., that have become essential components of sports and special events broadcasting such as parades, political conventions, etc. POV is especially important to the ABC Television Network. These frequencies are also quite often used as backhauls to network origination facilities if the remote is geographically close. Some examples cited for ABC are the New York City Marathon, Election and Convention coverage and sports remotes at the Meadowlands facility in northern New Jersey.

It is not only the channels themselves the use of which varies; the same camera and transmission system used one day for a "talking head" may be used the next day for a football game and the next to show the speed and force of hurricane wind. The channels may also be used for fixed microwave links such as Studio-To-Transmitter links and backbone video relay (inter-city relay) in less populous areas where ENG is less prevalent and especially where means such as regional cable systems and TV translators are needed to extend television service to remote communities.

Contribution Quality

"Contribution Quality" is generally defined as video program material that is originated from a remote location which can then can be inserted imperceptibly into locally generated studio program material. The material must be robust enough to survive multiple downstream production processes such as editing, compositing, keying or simply dubbing, in order to integrate the material, with locally generated studio programming, into a produced segment fit for transmission to affiliate stations. This segment may then be edited again by the affiliate station before being broadcast to the viewing public. If the acquired "Contribution Quality" material is electronically transmitted from the remote location, it is assumed that the output of the receiving device is a true, faithful reproduction of the input signal and is limited only by the quality of the acquisition format device and not by the transmission method.

"Contribution quality" material needs to be very high quality as the editing process must use some combination of analog tape, compressed digital tape or compressed video fileservers as a platform. The lowest bit rate we currently accept as a contribution NTSC digital transmission is 45 Mb/s (34 Mb/s in Europe) the DS3 standard for inter-city fiber optic video transmission service. Advanced compression techniques will lower the required bit rate to some extent. For example, the Panasonic DVC (Digital Video Cassette) introduced in 1995 operates at a video bit rate of 25 Mb/s. The Sony SX line operates at a video bit rate of 18.6 Mb/s. Note, however, that these numbers are for compressed video data only. Adding audio and error correction significantly increases the bit rate. HDTV will drastically increase the necessary bit rate.

Digital Transmission

For a digital transmission format to be robust enough to survive mobile or temporary fixed use in urbanized areas, where RF use is intensive and congested and where available non-engineered microwave paths are usually lossy and sometimes even completely obstructed, making techniques such as "building bounce" necessary, a robust modulation technique must be used. CCIR Report 934-2 and Recommendation 283-5 state that, for digital radios operating in 1.7 to 2.7 GHz over engineered terrestrial paths, 8 PSK modulation can be expected to yield a spectral efficiency of 2.1 bits/seconds/Hz. [8 PSK is theoretically capable of 3 b/s/Hz.] Higher throughputs are available for 16 QAM (2.7 b/s/Hz) and 64 QAM (5 b/s/Hz). Since engineered paths are not available for ENG use, and indeed very bad paths must sometimes be utilized, it is reasonable to assume (though not yet tested) that QPSK with a bit rate not over 1.4 b/s/Hz may have reasonable reliability in the presence of non-extreme multipath and channel nonlinearity conditions. This would allow a 19.5 Mb/s signal to fit into 14 MHz which, with a steep shaping factor of 1.2, yields a minimum occupied bandwidth of 17 MHz per channel. Higher reliability can be achieved by using an inner code of 1/2 instead of 3/4, which would reduce the bit rate to 2/3 or 13 Mb/s in the same 17 MHz channel. In short, for field production use, it appears that the digital transmission bandwidth must be comparable to or greater than the analog bandwidth.

If the existing 17 MHz channel bandwidth were to be reduced to 15, 12 or even 6 MHz, the digital data rate would need to be reduced accordingly. Although much more testing is needed, current indications are that higher modulation techniques, such as 16 QAM or 64 QAM, which allow more bits/Hz, are too fragile to survive the phase and amplitude distortions caused by transmission along paths typical of ENG use. News events are not limited to locations where ideal or line of sight microwave paths exist. This means that for robust digital transmission within 6 MHz we must limit the video bit rate to 7 Mb/s or below (4.6 Mb/s for the highest reliability).

ABC Engineering Laboratory

The ABC Engineering Laboratory has been in existence since 1963 as a part of the ABC Television Network's Broadcast Operations and Engineering support staff. Its primary purpose is to test and evaluate broadcast related equipment to determine whether a device meets applicable technical standards in addition to determining whether the equipment fulfills the technical and operating needs of the Network and the Capital Cities/ABC Owned and Operated Television Stations. We have evaluated equipment ranging from small cable connectors to large satellite distribution systems. We are proficient at testing all types of broadcast equipment including cameras, video cassette recorders, distribution amplifiers, video processing and conversion equipment, video and audio scrambling devices, etc. and are recognized throughout the broadcast industry as a highly regarded test and evaluation facility. Reports about the performance of the equipment are generated and sent to the engineering staff, select operations personnel and other key areas throughout the company. Reports are not generally supplied to the industry at large nor are all the conclusions and comparisons fed back to the manufacturer, however, many are given test results and criticisms so that they may confirm the accuracy of our tests and take our suggestions for future product enhancements.

Compression Test Methods

The ABC Engineering Lab has a significant amount of experience in testing compression encoders and decoders. We have a documented test methodology that includes subjective and objective video and audio performance, operational performance and ease of use, mechanical construction, environmental performance, electrical performance, RF interference and a number of other parameters. A prominent section of our testing involves subjective performance evaluations using our compression test tape. This tape contains either original source material or digital copies of original material encompassing the gamut of what is typically broadcast including pieces from entertainment, sports, graphics, news and film-to-tape transfers. Also included are test signals, specially shot camera sequences and charts, video effects and other specially generated sequences (see attached Table 1). The procedure for passing the material though the system under test is as follows:

The original source is a standard D2 digital tape. We use a Sony DVR-20 Digital Video Tape Recorder (DVTR) to play the tape. Depending on the type of video inputs and outputs the system under test has (the VideoLynx 2000 has both analog NTSC and parallel component digital I/O) the corresponding outputs of the DVTR will used. The VideoLynx 2000 was used in a back-to-back mode with the output of the compression encoder directly feeding the input of the compression decoder. The output of the compression decoder is then recorded on a second Sony DVR-20. Since the VideoLynx 2000 has 2 sets of inputs we performed the test both ways, first using the analog I/O, then using the component digital I/O. The component digital I/O of the VideoLynx 2000 required that we use a Sony BKPF-131 digital decoder to convert the composite DVTR to component digital. The return path required a Sony BKPF-132 digital encoder to convert from component digital back to composite for recording on the second DVR-20. Both of these paths, the analog path and the digital path, are characterized from DVTR to DVTR and the performance of each are known, established and quantified. We then carefully synchronize the original tape with the encoded tape and compare them on two matched, Sony BVM-1910 high resolution monitors. The process is then repeated on multiple passes through the system by feeding the first pass tape back through again. This gives us a good indication of performance should the material be subjected to multiple compression processes. Every time a digital signal is to be moved between production facilities electronically in limited bandwidth channels, recompression will be necessary, and the artifacts (degradations) are cumulative.

ABC Evaluation Findings of the Comsat/Wegener VideoLynx 2000

The ABC Engineering Laboratory received a prototype of the Comsat/Wegener VideoLynx 2000 compression system in July, 1995. The VideoLynx 2000 encoder and decoder were each 3 rack units high, weighed 30 lbs and were not mounted in weatherproof packages. The system was an early prototype and contained a number of operational, mechanical and electrical performance problems[1]. Comsat/Wegener has acknowledged these problems and indicated that many of these issues would be addressed in the production unit. A complete copy of our findings was provided to them on September 12, 1995. The problems identified by Comsat/Wegener, however, did not include the compression algorithms and processes employed in the VideoLynx 2000. Comsat/Wegener indicated that these compression algorithms and processes would not change in the final product. It was agreed that a production unit would return to our laboratory and we would revisit the operational problems present in the original prototype to see if they had been addressed. This has not happened to date. As indicated by Comsat/Wegener's own statements, however, the final version is not expected to alter the performance of the VideoLynx 2000 insofar as its compression algorithms and processes are concerned.

The following observations were made about the single pass performance of the VideoLynx 2000 compressed and decompressed at 6 Mb/s data rate (units connected back-to-back, with no RF path involved):

- A subjective comparison between the original material and the compressed/decompressed material shows that artifacts are readily apparent in video with high detail and motion including graphics and sports material. These artifacts are mainly pixel blocking at luminance transitions or defined more simply, hard, square edges not present on the original material that gives the video an unwanted, digital look. Chrominance (color) resolution, both horizontally and especially vertically, is reduced. At normal play rates, much of the news and entertainment material appears fair with only a slight reduction in luminance resolution. Slow motion playing or jogging (stepping frame by frame) through these scenes clearly demonstrates the artifacts. Artifacts are objectionable in all material during subsequent compression processes

The following observations were made about the single pass performance of the VideoLynx 2000 compressed and decompressed at 12 Mb/s data rate (units connected back-to-back, with no RF path involved):

- Artifacts are noticeable at normal play speed on graphic material with sharp moving edges and on wipes between highly detailed video scenes. Artifacts are noticeable on sports and other detailed video when jogging or playing at slow-variable play speeds. Artifacts become readily apparent on all video on the second and subsequent compression processes. Chrominance resolution does not improve over the 6 Mb/s data rate.

The following observations were made about the single pass performance of the VideoLynx 2000 compressed and decompressed at 15 Mb/s data rate (units connected back-to-back, with no RF path involved):

- Performance is very similar to 12 Mb/s rate with a minimal, almost unnoticeable decrease in artifacts.

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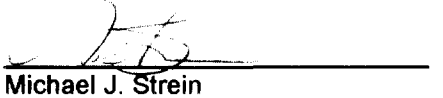
[1] The size and weight of the production encoder, according the published specifications, have not changed significantly from the prototype. For applications such as POV cameras mounted in race cars and the like, this size, weight and packaging is totally unusable.

The following comments concern the operational performance of the VideoLynx 2000 at any data rate. At the very least, to solve these problems would require a major redesign of the VideoLynx 2000, which Comsat/Wegener has not indicated it plans to do.

- The VideoLynx 2000 only passes 480 of the 525 lines required for NTSC video. Many transmission manufacturers commonly discard lines 1 through 10, which contain the equalization pulses required for vertical synchronization, choosing instead to regenerate these lines at the receiver. Comsat/Wegener discards lines 11 through 21, commonly referred to as the Vertical Blanking Interval (VBI), as well as active lines 261, 262, and 263 (half line) during both fields (background note: NTSC is an interlaced format. 262.5 lines 60 times per second generate the effective 525 line, 30 frame rate.) This results in several problems: a loss of several active video lines, a loss of the VBI lines through which we separately encode and transmit affiliate data but, probably most importantly, the loss of Closed Captioning on line 21. If the VideoLynx 2000 is used as a Studio-To-Transmitter Link, the resultant broadcast signal will be stripped of the Closed Captioning information. It is important to note that, aside from the lossy effects of the compression process, the output signal is not a replication of the source material because of the missing lines.
- The VideoLynx 2000 exhibits a significant amount of latency (delay) that is dependent on the data rate employed in the unit. At 6 Mb/s the delay from encoder to decoder is approximately 1.5 seconds. This delay, coupled with the satellite transmission delay and any subsequent delays generated in the studio, will cause a significant, noticeable delay. This becomes an issue when the unit is used in a 2-way ENG or SNG application (where the anchor in the news studio talks with the news reporter in the field - a fairly common scenario). Long, cumbersome and clumsy pauses in conversation result when the delays become excessive. This would be especially disconcerting for guests not located in the studio in interview shows The latency is due to the significant amount of processing occurring in the VideoLynx 2000. The latency decreases to approximately 0.5 seconds at 15 Mb/s data rate. This is not a factor with analog transmission systems.
- Another problem that can occur when using the system is recovering from RF signal fading during transmission. RF problems are a common occurrence, and traditional analog systems recover quickly from disturbances. RF problems in the transmission path require the VideoLynx 2000 to reset and resync creating a minimum delay of a few seconds, a long time when the broadcast is live. The encoder is also very sensitive to disturbances at the input. If the video input to the VideoLynx 2000 is changed through a switch not locked to a common reference (very typical at remote locations) the system requires a few seconds to reset. If a noisy feed is input to the VideoLynx 2000 (also very typical) the system will lock up and require manual resetting. This makes the system unreliable whenever the unit is sent video from a camera via a non-wired path, since a common momentary signal disturbance would lock up the unit.
- The VideoLynx 2000 uses MPEG Layer-2 audio compression. It is general and prudent policy not to use audio compression in an acquisition format. It is quite possible that audio compression will be employed downstream in distribution and studies have shown that audio concatenation artifacts become noticeable and objectionable very quickly.

I declare under the penalty of perjury that the foregoing is true and correct.



Michael J. Strein

5/16/96

Date